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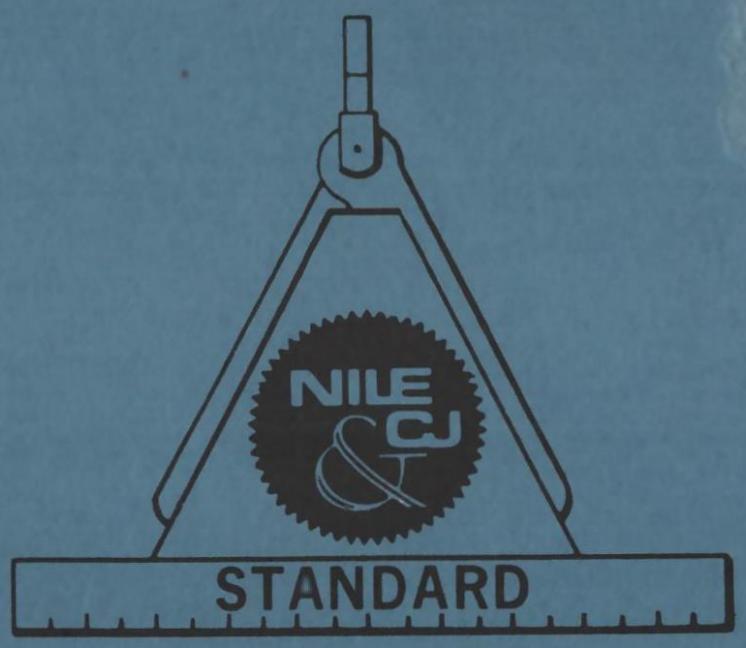
MARCH 1972

LAW ENFORCEMENT STANDARDS PROGRAM

BALLISTIC RESISTANCE OF POLICE BODY ARMOR



U.S. DEPARTMENT OF JUSTICE
Law Enforcement Assistance Administration
National Institute of Law Enforcement and Criminal Justice

LAW ENFORCEMENT STANDARDS PROGRAM

NILECJ STANDARD ON THE BALLISTIC RESISTANCE OF POLICE BODY ARMOR

A Voluntary National Standard Promulgated by the National Institute of Law Enforcement and Criminal Justice.

MARCH, 1972

U.S. DEPARTMENT OF JUSTICE

Law Enforcement Assistance Administration
National Institute of Law Enforcement and Criminal Justice

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This standard was formulated by the Law Enforcement Standards Laboratory of the National Bureau of Standards under the direction of Jacob J. Diamond, Manager, Protective Equipment Program and Mr. Myron G. Domsitz, Acting Chief of LESL. Technical research was performed by the staff of the NBS Product Evaluation Technology Division under the supervision of Nicholas J. Calvano. Data in the sampling tables were taken from "Military Standard: Sampling Procedures and Tables for Inspection by Attributes" (MIL-STD 105D, issued by the Department of Defense, April 29, 1963), and modified, as appropriate, by Dr. John Mandel, Applied Mathematics Division of NBS and Marc A. Nerenstone of the National Institute of Law Enforcement and Criminal Justice.

NILECJ Standard on the Ballistic Resistance of Police Body Armor

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FOREWORD

In accordance with Title I, Section 402(b) of the Omnibus Crime Control and Safe Streets Act of 1968, P.L. 90-351, the National Institute of Law Enforcement and Criminal Justice (NILECJ) has established the Law Enforcement Standards Laboratory (LESL) at the National Bureau of Standards.

LESL has been established to conduct research leading to the development and promulgation of national voluntary equipment standards that will assist law enforcement and criminal justice agencies in the selection and procurement of quality equipment. In addition to standards development, LESL is defining minimum performance levels and developing methods for measuring the required performance of equipment designated by NILECJ.

This document, NILECJ Standard 0101.00 on the Ballistic Resistance of Police Body Armor, is the first law enforcement standard developed by LESL and issued by NILECJ. Additional standards, as well as user guidelines, state-of-the art surveys, and other reports are planned for issuance under the LESL program in the areas of protective equipment, communications equipment, security systems, weapons, emergency equipment, concealed objects detectors, and vehicles.

NILECJ Standards are subjected to continuing review. Technical comments and recommended revisions are invited from all interested parties. Suggestions should be addressed to the Program Manager for Standards, National Institute of Law Enforcement and Criminal Justice, Law Enforcement Assistance Administration, U.S. Department of Justice, Washington, D.C. 20530.

NILECJ-STD-0101.00
April 1, 1972

NILECJ STANDARD
on the
BALLISTIC RESISTANCE OF POLICE BODY ARMOR

1. PURPOSE AND SCOPE

The purpose of this document is to establish voluntary, standard performance requirements and methods of test for the ballistic resistance of police body armor. This standard deals with ballistic penetration and deformation of armor intended to protect the torso against small arms fire.

2. CLASSIFICATION

2.1 Type

Police Body Armor may be made from a variety of materials which resist ballistic penetration, and are designed to resist maximum threats which range in severity from the caliber .38 Special lead to the caliber .30-06 armor piercing rounds. In general, the greater the resistance to ballistic penetration, the greater the cost and weight of the armor. Police Body Armor covered by this standard shall be classified into three types, by level of performance. Table 1 summarizes the protection they afford.

2.1.1 Type .22 LR–.38 Special

This armor protects against the standard threats as defined in paragraph 4.2.1. It also provides protection against lesser threats such as caliber .22, .25, .32, and .45 standard handgun rounds and 12 Gauge No. 4 shot.

2.1.2 Type .357 Magnum

This armor protects against the standard threat as defined in paragraph 4.2.2. It also provides protection against lesser threats such as 9mm Luger and 12 Gauge 00 Buckshot, as well as the threats mentioned in paragraph 2.1.1.

2.1.3 Type .30 AP

This armor protects against the standard threat as defined in paragraph 4.2.3. It also provides protection against lesser threats such as caliber .41 Magnum and .44 Magnum handgun, and caliber .30 carbine rounds, and the 12 Gauge Rifled Slug, as well as the threats mentioned in paragraphs 2.1.1 and 2.1.2. Current type .30 AP armor is composed

of a ceramic front element bonded to a nonceramic rear element. In the process of defeating the projectile, the ceramic front element is rendered ineffective by one or a very few rounds; the residual protection is then that of the nonceramic rear element, normally that of type .357 Magnum armor.

2.2 Configuration

Police Body Armor is offered in a variety of configurations. All makes and models offer protection for the torso front. Many models also cover the back, and some offer additional protection. Police Body Armor may be specified to contain armor parts to cover the:

(a) torso front,
(b) torso back,
(c) groin,
(d) coccyx

or any practical combination of these, as required.

TABLE 1.—*Protection Afforded by Police Body Armor*

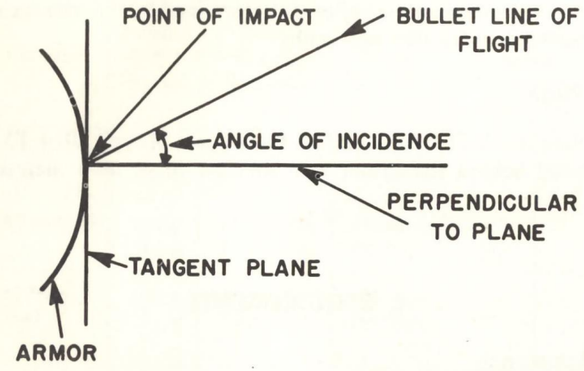
Threat	Protection Afforded		
	Type .22 LR-.38 Spec. Armor	Type .357 Magnum Armor	Type .30 AP Armor
.22 LRHV(R)	YES	YES	YES
.38 Special MP	YES	YES	YES
.22 LRHV(P)	YES	YES	YES
.25 ACP	YES	YES	YES
.32 ACP	YES	YES	YES
.45 ACP	YES	YES	YES
12 Gauge #4 Shot	YES	YES	YES
.357 Magnum lead	NO	YES	YES
9 mm Luger	NO	YES	YES
12 Gauge 00 BK	NO	YES	YES
.30-06 AP	NO	NO	YES
.41 Magnum	NO	NO	YES
.44 Magnum	NO	NO	YES
.30 Carbine	NO	NO	YES
12 Gauge RS	NO	NO	YES

Abbreviations: ACP: Automatic Colt Pistol
AP: Armor Piercing
BK: Buckshot
LRHV: Long Rifle High Velocity
MP: Metal Point
(P): Pistol
(R): Rifle
RS: Rifled Slug

3. DEFINITIONS

3.1 Angle of Incidence

The angle of incidence is the angle between the line of flight of the bullet and the perpendicular to the plane tangent to the point of impact. See figure 1.



ANGLE OF INCIDENCE
FIGURE 1

3.2 Armor Piercing Bullet

A bullet containing a hard steel core and a full metal jacket of gilding metal (90% copper alloy), designed for high penetrating power.

3.3 Deformation

Deformation is the maximum momentary change in the shape of the inner surface of a ballistic element caused by a fair hit that does not penetrate the armor.

3.4 Deformation Block

The deformation block is a block of nonhardening modeling clay, 25 cm by 25 cm by 5 cm thick (10 in by 10 in by 2 in).

3.5 Fair Hit

A fair hit is one that impacts the armor at an angle of incidence no greater than 5 degrees, and is no closer to the edge of the armor part or to a prior hit than 5 cm (2 in).

3.6 Lead Bullet

A bullet made of lead alloyed with hardening agents.

3.7 Metal Point Bullet

A bullet consisting of a lead alloy core, with that portion of the bullet protruding from the cartridge case protected from deformation by a harder metal alloy covering.

3.8 Penetration

Penetration of the ballistic test specimen is defined as the perforation of the witness plate by any part of the armor or test bullet, as determined by the passage of light when the witness plate is held up to a 60-watt light bulb.

3.9 Witness Plate

A witness plate is a 0.51 mm (0.020 in) thick sheet of type 2024-T3 or 2024-T4 aluminum alloy placed behind the armor specimen to serve as a means of determining penetration.

4. REQUIREMENTS

4.1 Quality Assurance

4.1.1 Lot by Lot Inspection

A sample of each lot shall be taken for test at random, using a table of random numbers or an equivalent procedure. The number of complete armors selected for test from each lot may be in accordance with the table below. This table is considered to be a reasonable compromise between an acceptable level of quality and the cost of testing. However, any desired sample size may be selected by the purchaser, and should be specified in the purchase document. For a discussion of the statistical considerations, see appendix A.

Lot Size (units)	*Sample Size* (units)
1–8	1
9–15	2
16–25	3
26–50	5
51–90	8
91–150	13
151 or more	20

4.1.2 Quality Control Procedure

Manufacturers of Police Body Armor may elect to maintain quality control charts on their production, tested in accordance with this standard, and make these records available to the purchaser or his representative. If agreed to by the purchaser and manufacturer, quality may be assured by inspection of these records rather than under lot by lot inspection (par. 4.1.1).

4.2 Resistance to Ballistic Penetration

The contents of this paragraph are summarized in table 2.

TABLE 2.—*Test Summary*

Test Variables					Performance Requirements		
Armor Type	Cartridge	Nominal Bullet Weight	Barrel Length Suggested	Minimum Bullet Velocity	Penetration per Armor Part		Deformation
					Fair Hits	Penetration	
.22 LR–.38 Spec.	.22 LRHV(R) lead	2.6 g 40 gr	56 ±1.5 cm 22 ±0.6 in	360 m/sec 1181 ft/sec	5*	0	Not yet established.
	.38 Spec. MP	10.2 g 158 gr	20 ±1.5 cm 7.9±0.6 in	238 m/sec 782 ft/sec	5*	0	
.357 Mag.	.357 Mag. lead	10.2 g 158 gr	20 ±1.5 cm 7.9±0.6 in	384 m/sec 1261 ft/sec	5*	0	Not yet established.
.30 AP	.30-06 AP	10.8 g 166 gr	56 ±1.5 cm 22 ±0.6 in	821 m/sec 2694 ft/sec	1	0	Not yet established.

*Armor fronts shall be impacted with 10 fair hits.

Abbreviations:
AP: Armor Piercing
g: Grams
gr: Grains
LRHV: Long Rifle High Velocity
Mag.: Magnum
MP: Metal Point
(R): Rifle
Spec.: Special

4.2.1 Type .22 LR–.38 Special

Armor shall be tested for resistance to ballistic penetration according to the procedure in paragraph 5.1. Two test weapons shall be used. The first weapon shall be a caliber .22 rimfire rifle or test barrel. The use of a rifle with a 56.0±1.5 cm (22.0±0.6 in) barrel is suggested. Test bullets shall be caliber .22 Long Rifle High Velocity lead and shall have nominal weights of 2.6 g (40 gr) and nominal muzzle velocities ot 392 meters (1,285 ft) per second.

The second test weapon shall be a test barrel or a handgun capable of firing caliber .38 Special cartridges. The use of a handgun with a barrel 20.0±1.5 cm (7.9±0.6 in) in length is suggested. Test bullets shall be metal point and have nominal weights of 10.2 g (158 gr) and nominal muzzle velocities of 261 meters (855 ft) per second.

Each part of each armor in the test sample shall be subjected to fire from the first test weapon until it has been impacted with the required number of fair hits by rounds with measured velocities equal to or greater than 360 meters (1,181 ft) per second. The armor

front shall be impacted with ten fair hits. Other armor parts (such as back and groin protector) shall be impacted with the greatest number of fair hits possible up to a maximum of five. The hits on each armor part shall be spaced as evenly as possible in order that every portion be subjected to test.

Penetration by any fair hit, no matter what its velocity, shall cause rejection of the lot.

If the armor passes the test by the first test weapon, it shall be tested with the second test weapon. The same detailed requirements shall apply, except that rounds with minimum velocities of 238 meters (782 ft) per second shall be used.

4.2.2 Type .357 Magnum

Armor shall be tested for resistance to ballistic penetration according to the requirements of paragraph 4.2.1, with the following changes. The test weapon shall be a caliber .357 Magnum test barrel or a revolver with a suggested barrel length of 20.0 ± 1.5 cm (7.9 ± 0.6 in); the test bullets shall be caliber .357 Magnum lead having nominal weights of 10.2 g (158 gr) and nominal muzzle velocities of 430 meters (1,410 ft) per second; rounds with minimum velocities of 384 meters (1,261 ft) per second shall be used.

4.2.3 Type .30 AP

Armor shall be tested for resistance to ballistic penetration according to the requirements of paragraph 4.2.1 with the following changes. The test weapon shall be a caliber .30-06 test barrel or a rifle with a suggested barrel length of 56.0 ± 1.5 cm (22.0 ± 0.6 in); the test bullets shall be military caliber .30 AP M2 rounds (Military Specification MIL-C-1217) having nominal weights of 10.8 g (166 gr) and nominal velocities at 24 meters (78 ft) of 828 meters (2,715 ft) per second; each part (front, back, etc.) of each armor in the test sample shall be subjected to a single impact by a round with a minimum muzzle velocity of 821 meters (2,694 ft) per second.

4.3 Ballistic Deformation

The determination of minimum performance requirements for ballistic deformation resistance is underway. When this information is available, this paragraph will be amended.

4.4 Workmanship

Armor shall be free from wrinkles, blisters, cracks, crazing, fabric tears, chipped or sharp corners, and other evidences of inferior workmanship.

4.5 Marking

Each armor part shall be clearly and durably marked with the manufacturer's name, brand name or logo, the model number, and the lot number.

5. TEST METHODS

5.1 Ballistic Penetration Test

The ballistic penetration test consists of firing the specified bullet at the armor through a pair of triggering devices which are a known distance apart and serve, respectively, to start and stop a chronograph. If the shot results in a fair hit, the witness plate behind the test specimen is examined for evidence that the test specimen has been penetrated.

5.1.1 Equipment

5.1.1.1 Test Setup

A diagram of the ballistic penetration test setup is shown in figure 2.

5.1.1.2 Test Weapon Support

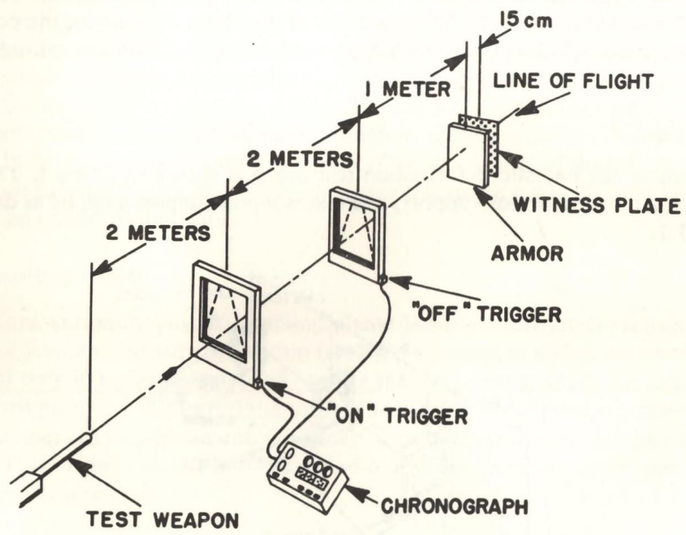
The test weapon shali be firmly clamped, with the barrel horizontal, in such a manner that the alignment of the weapon is not altered by the firing of the weapon.

5.1.1.3 Chronograph

A chronograph shall be used to measure the time interval between the bullet's activation of the first and second triggering devices with a precision of 1 microsecond and an accuracy of 2 microseconds.

5.1.1.4 Triggering Devices

The triggering devices may be of either the photoelectric or conductive screen types. They shall define planes perpendicular to the line of flight of the bullet, and be 2 and 4 meters (6 and 13 ft), respectively, from the muzzle of the test weapon. The distance between them shall be measured with an accuracy of 1.0 mm (0.05 in). The time of flight and distance measurements shall be used to calculate the velocity of each test round.



BALLISTIC PENETRATION TEST SETUP

FIGURE 2

5.1.1.5 Armor Support

The armor part under test shall be supported in a device which permits its position and attitude to be readily adjusted so that the ballistic element under test is perpendicular to the line of flight of the bullet at the point of impact and is 5 meters (16 ft) from the muzzle of the test weapon.

5.1.1.6 Witness Plate

The witness plate shall be placed and rigidly affixed perpendicular to the line of flight of the bullet and 15 cm (6 in) beyond the armor specimen under test.

5.1.2 Test Procedure

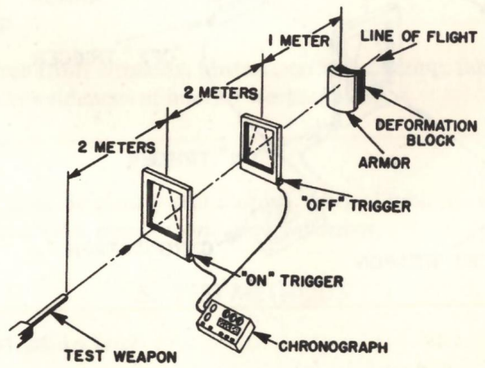
After the specified test weapon has been clamped, leveled and positioned, one or more pre-test rounds (as needed) shall be fired through a witness plate to determine the line of fire. An armor specimen and an unperforated witness plate shall then be placed in position and a test round fired. The time of flight of the bullet as indicated by the chronograph shall be recorded, the witness plate examined to determine penetration, and the armor specimen examined to see if the bullet made a fair hit. If no penetration occurred, the armor shall be repositioned or another armor specimen positioned (as required) and the procedure repeated with additional test rounds until the test is completed.

5.2 Ballistic Deformation Test

The ballistic deformation test consists of firing the specified bullet at the armor through a pair of triggering devices which are a known distance apart and serve respectively to start and stop a chronograph. After each fair hit the deformation block in contact with the back of the armor specimen is examined for evidence of deformation caused by impact of the bullet.

5.2.1 Equipment

A diagram of the ballistic deformation test setup is shown in figure 3. The chronograph, triggering devices, armor support, and test weapon support shall be as described in paragraph 5.1.1.



BALLISTIC DEFORMATION TEST SETUP

FIGURE 3

5.2.1.1 Deformation Block

The deformation block shall be conditioned by being kept for at least three hours at a temperature of 23 ± 2 °C (73.5 ± 3.5 °F). It shall then be pressed into intimate contact with the back of the armor specimen under test, positioned so that the centers of the larger faces are in the line of flight of the bullet.

5.2.2 Test Procedure

The test procedure for determining ballistic deformation shall be the same as that for ballistic penetration (par. 5.1.2) except that the deformation block shall be used instead of the witness plate. After each fair hit, the deformation block shall be separated from the armor and the depression caused by the armor deformation shall be examined.

A plaster cast of the depression in the deformation block shall be made by filling it with a Plaster of Paris slurry. The slurry shall be made by adding dry Plaster of Paris to water, without stirring, until the water is completely absorbed and then stirring until the slurry is smooth. When the plaster cast has hardened, it shall be removed from the clay and its dimensions measured. The depth of the depression, its diameter and its general shape (i.e., hemispherical, elliptical, pyramidal, etc.) shall be recorded.

APPENDIX A

A.1 General Principles of Sampling

In most cases, and in particular in the case of destructive testing, 100% testing is impractical or impossible, and assurance of the quality of a lot must be obtained by the testing of a properly selected sample. When a sample is taken at random from a lot, the information obtained by testing the sample is to a good approximation largely independent of the size of the lot, provided the lot is at least five times the size of the sample. On the other hand, the information provided by such a random sample depends crucially on the absolute size of the sample, and not on the ratio of its size to that of the lot. Thus, a random sample of ten items provides essentially the same information whether the lot size be one hundred or one hundred thousand.

A.2 Sampling Plans

There are various types of sampling plans. Here we restrict ourselves to the consideration of sampling by attributes, that is, to the situation in which the result of the test is expressed only in terms of "pass-fail" rather than as a numerical test result. A sampling plan is described by specifying (a) the sample size, (b) the acceptance number and (c) the rejection number. In this document, the acceptance number is zero and the rejection number is one. This means that the lot is accepted only if no specimen in the sample fails; it is rejected if one or more fail.

A.3 Operating Characteristic (OC) Curves

Sampling plans are best described by OC curves. For each possible lot quality as expressed by the percentage of defective items in it (OC curve abscissa), the OC curve gives the probability that such a lot will be accepted by the sampling plan (OC curve ordinate). Figure 4 gives the OC curves for sample sizes 2 to 20. See Section 4.1.1.

A.4 References

For further discussion see:

[1] "The Statistical Analysis of Experimental Data," by John Mandel, Interscience Publishers (John Wiley and Sons), New York, 1964, pp. 224-230.

[2] "Statistical Methods in Research and Production," by Owen L. Davies, Hafner Publishing Co., New York, 3d Edition, 1967, pp. 330-336.

OPERATING CHARACTERISTIC CURVES FOR SELECTED SAMPLE SIZES

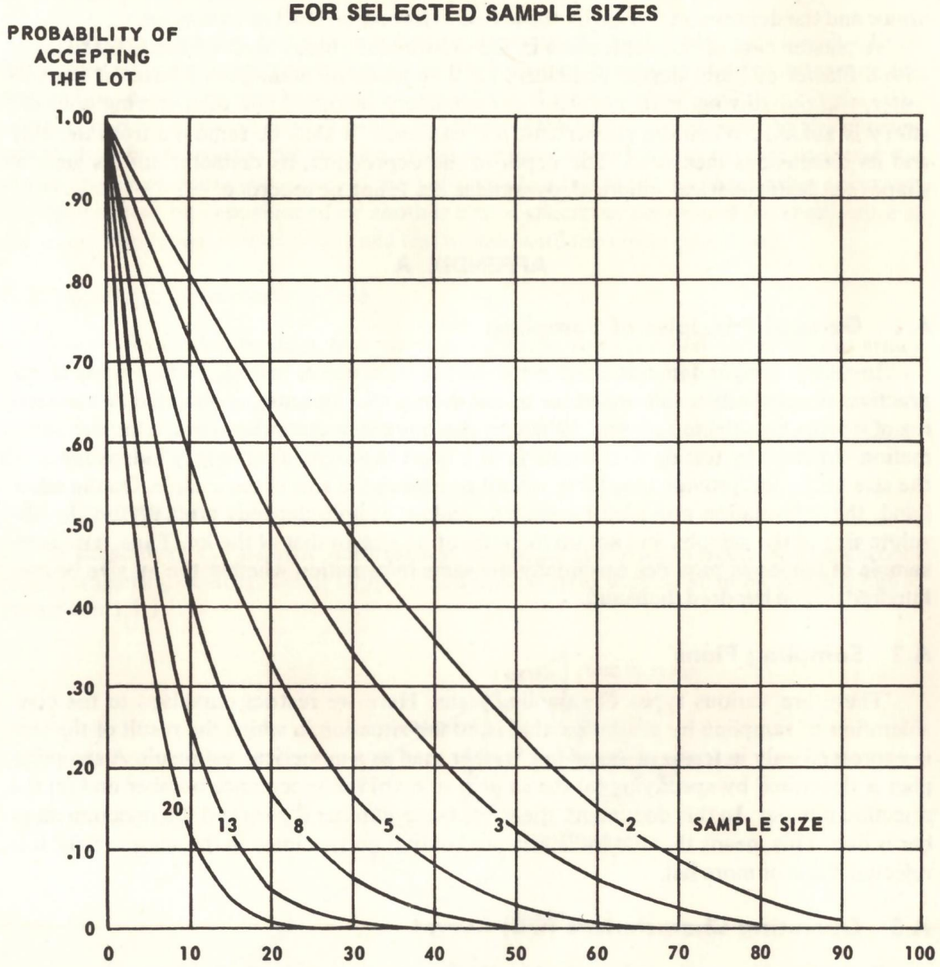


FIGURE 4

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